TECHNICAL REVIEWERS' RATING SUMMARY

G-010-C
"Vertical Seismic Profiling Test of Seismic Fault and Fracture Detection in the Bakken Formation"
Submitted by: Marathon Oil Company
Principal Investigator: Chuck Meeder & Chris Tuttle
Request for $150,000; Total Project $300,000
Duration: 5 months

Rating Category	Weighting Factor	Technical Reviewer 10C-01	10C-02 Rating	10C-03	Average Weighted Score
Objective	9	3	4	3	30.0
Achievability	9	3	4	4	33.0
Methodology	7	3	4	4	25.7
Contribution	7	2	4	3	21.0
Awareness	5	3	3	3	15.0
Background	5	5	4	5	23.3
Project Management	2	3	3	5	7.3
Equipment Purchase	2	5	4	5	9.3
Facilities	2	3	4	4	7.3
Budget	2	3	4	5	8.0
Average Weighted Score		157	193	190	**179.9**
Maximum Weighted Score		250	250	250	**250**

OVERALL RECOMMENDATION

FUND			
FUNDING TO BE CONSIDERED	**X**	**X**	**X**
DO NOT FUND			

G-010-C

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Submitted by: Marathon Oil Company
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Section B. Ratings and Comments:

1. The objectives or goals of the proposed project with respect to clarity and consistency with North Dakota Industrial Commission/Oil and Gas Research Council goals are: 1 – very unclear; 2 – unclear; 3 – clear; 4 – very clear; or 5 – exceptionally clear. Please comment:

Reviewer 10C-01 (Rating: 3)
This project appears to meet the requirements of the NDIC/Oil and Gas Research council to help the oil and gas industry in North Dakota. Utilizing seismic data to locate faults and fractures, if successful, should help oil and gas operators drill more successful wells. More economically successful wells equates to more jobs and greater job security for the energy industry in North Dakota. It will encourage more use of this technology if successful. In fact, for this technology to be utilized to its greatest potential, this must be repeated in other areas to accommodate lateral changes in lithology and vertical changes in the stratigraphy.

Marathon's Response
Testing this technology in more than one area is ultimately expected to be beneficial. However, encouragement at this location can motivate trial use of 3D seismic and additional tests elsewhere.

Reviewer 10C-02 (Rating: 4)
The objective of this project is very clear, and if successful would be consistent with the goals of the NDIC/OGRC.

Reviewer 10C-03 (Rating: 3)
The objective description looks clear. Meanwhile, further in the text it appears that the results of the study are hoped to provide some knowledge on fracture direction which is supposed to be a major problem needing solution. I believe that it would be a success if fracture zone will be detected and I doubt that seismic surveys are capable of providing information on fracture directions. I also doubt applicability of the results to a broader area within Bakken. Thus consistency with NDIC Oil and Gas Research Council seems to be average.

Marathon's Response
Seismic has provided evidence for mapping fracture zones, and very small offset faults in other areas. The reason for testing the concept is to apply it to an area where Bakken production has been identified and then extrapolate to other areas within the Bakken where fracture orientation may vary.

2. With the approach suggested and time and budget available, the objectives are: 1 – not achievable; 2 – possibly achievable; 3 – likely achievable; 4 – most likely achievable; or 5 – certainly achievable. Please comment:

Reviewer 10C-01 (Rating: 3)

The timetable and cost estimate seems reasonable, if the job goes as planned. This type of service is mainly sensitive to availability of equipment relative to the drilling progress. Close coordination between the VSP vendor and the drilling personnel is very important to insure availability and to reduce stand-by costs related to delays. The total cost of the VSP service will be quite sensitive to delays waiting on equipment or equipment problems because of the high cost of drilling rig time in the current market. The proposal indicates the VSP vendor, but does not indicate the service point for the equipment. This can become a significant risk if the service point is located distant from the well, especially considering traveling to the job during the winter months.

Marathon's Response
The vibroseis seismic source trucks are planned to be mobilized from Wyoming and the downhole seismic equipment from Victoria, Texas. The VSP is a normal wireline service that is regularly coordinated with the completion of drilling and other wireline logging services. Schlumberger says the equipment is available at the expected time, and they can adjust their equipment schedule e to meet our needs with good communication and coordination. Marathon has performed these operations in other areas of operation.

Reviewer 10C-02 (Rating: 4)
The objective of the project is to test the viability of using VSP for fracture and fault detection to enhance the drilling and development of the Middle Bakken. After the data has been analyzed the viability of using VSP in the Middle Bakken will be known.

Reviewer 10C-03 (Rating: 4)
The objectives as they outlined are most likely achievable. However if one hopes to make inferences to fracture geometry achievability of the goal can be doubted (see #1).

Marathon's Response
It is not expected that the VSP will determine fracture orientation, but test seismic detection of fracture zones and small faults observed in the well. The VSP would then provide seismic calibration and lead to mapping of the fracture zones with 3D seismic.

3. The quality of the methodology displayed in the proposal is: 1 – well below average; 2 – below average; 3 – average; 4 – above average; or 5 – well above average. Please comment:

Reviewer 10C-01 (Rating: 3)
It appears from the information provided, that the investigators are suggesting this VSP profile method to prove up a concept that it could be used to map fracture trends and fault location and orientation. This data in turn would be used to help orient the horizontal wellbores and improve well trajectory control in the area of faults. This would be accomplished by correlation of arrival times to known depths within the vertical well and then apparently use those velocity and time relationships to refine additional seismic data from along the horizontal borehole in an effort to identify fractures and faults identified by other methods within the horizontal wellbore. Correct identification of the fractures and faults appears to be proof of concept. That may place this project partially in the realm of research, rather than entirely in technology application. That does not preclude this project from consideration, but does increase the risk associated with funding the project versus the reward of useful data. Even if not proven effective for the objectives of the project, the VSP data would still be useful to other operators for other aspects of seismic interpretation within the Williston basin. This would be probably be limited to adjacent areas with similar overlying vertical stratigraphy and lithology.

Marathon's Response
The overlying stratigraphy and lithology are not as important for this application as the rock physical properties and facture/fault density of the Bakken interval. Indeed, the data results do have other applications to oil and gas exploration and production in the areas that are beyond the Bakken formation.

Reviewer 10C-02 (Rating: 4)
Applications of seismic data have increased significantly. As the investigators have stated, this is a good tool for testing seismic detection limits and if the technology can be applied to the Middle Bakken.

Reviewer 10C-03 (Rating: 4)
The described methodology is reported to be efficient for the solution of problems of this kind. It can be considered to be a cutting age technology. However, it looks like the study will be focused on quite a small area and extension can be difficult. The authors do not specify how the extension might be made.

Marathon's Response
Extension will be made by calibration to 3D seismic which is beyond the scope of this proposal and additional VSPs in other areas where additional calibration is found to be necessary.

4. The scientific and/or technical contribution of the proposed work to specifically address North Dakota Industrial Commission/Oil and Gas Research Council goals will likely be: 1 – extremely small; 2 – small; 3 – significant; 4 – very significant; or 5 – extremely significant. Please comment:

Reviewer 10C-01 (Rating: 2)
The scientific contribution as a research project would address the NDIC/Oil and Gas Research Council goals in that it would prove up the concept. However, as is the usual case with research, verification by others would be necessary before it should become part of proven technology for this area. In regard to advancing the use of technology, the generation of VSP data will be useful for the oil and gas industry for interpretation of seismic data, and if the concept is proven, useful for the proposed purpose as well.

Marathon's Response
Verification is expected to come through application by Marathon and other industry operators. Proof of the concept and the chance to improve drilling and production success will motivate application.

Reviewer 10C-02 (Rating: 4)
If the project is successful it would be very significant in meeting the goals of the NDIC/OGRC.

Reviewer 10C-03 (Rating: 3)
The study contributes to the understanding of the Bakken formation structure and thus to NDIC Oil and Gas Council goals. However, the areal limits of the study limit its significance as well.

Marathon's Response
A successful initial test would encourage additional testing in Marathon's other areas of interest in the Bakken play and the application of seismic to reduce risk.

5. The principal investigator's awareness of current research activity and published literature as evidenced by literature referenced and its interpretation and by the

reference to unpublished research related to the proposal is: 1 – very limited; 2 – limited; 3 – adequate; 4 – better than average; or 5 – exceptional. Please comment:

Reviewer 10C-01 (Rating: 3)
There are no references to published data in the submitted proposal. However, both of the investigator's knowledge of VSP application and related seismic technologies seems acceptable and both have a long work history in the field. They also work for a global major oil and gas operator with a technology group to use as additional resources. The vendor chosen for the VSP services is also recognized as an industry leader in the area of VSP technology.

Reviewer 10C-02 (Rating: 3)
The investigators did not reference any literature, but it appears they are knowledgeable of the research activity concerning VSP.

Reviewer 10C-03 (Rating: 3)
The principal investigator awareness can't be assessed properly because no references are given. However, taking into account the quality of the chosen technique and investigator's experience I grade it to be adequate.

Marathon's Response
Marathon Oil has been investigating and testing seismic fracture detection methods over a period of more than 8 years. The references listed below represent some of this effort.

B. Golden, K.K. Sekharan, R. Wiley, C. Meeder, and K. Al-Rufaii, 'Fracture Detection Using a 3D RVSP Acquisition Method', EOS Trans. AGU 81 (48), Fall Meeting, 2000. A physical model study motivated, designed and supported by Marathon Oil.

The publications below from Stanford University are based on a project initiated by Chuck Meeder and supported by Marathon Oil and a DOE grant. Marathon Oil and Chuck Meeder are acknowledged for participation and support. Test areas include Yates Field, west Texas, and the Neuville (James Lime) Field, east Texas.

G. Mavko, D. Sava, J. Florez, and T. Mukerji, 'Integrated Seismic/Rock Physics Approach to Characterizing Fractured Reservoirs', GasTIPS, Gas Technology Institute, DOE, Summer 2005, p. 6-10.

D. Sava 'Quantitative Data Integration for Fracture Characterization Using Statistical Rock Physics', PhD dissertation, Standard University, 2004. Chuck Meeder and Marathon Oil are acknowledged for participation and support. This work is part of the above GasTIPS article.

J. Florez-Nino, and G. Mavko, 'Identification of Small Faults by Combination of LWD and VSP Data', Stanford Rock and Borehole Physics Meeting, June 2005.

Marathon, specifically Chuck Meeder and others, has also been testing seismic fracture detection testing and analysis including VSP and 3D seismic technology on proprietary projects.

6. The background of the investigator(s) as related to the proposed work is: 1 – very limited; 2 – limited; 3 – adequate; 4 – better than average; or 5 – exceptional. Please comment:

Reviewer 10C-01 (Rating: 5)

Both investigators have submitted that they have a long history of involvement with seismic technologies in the oil and gas exploration and production industry.

Reviewer 10C-02 (Rating: 4)
The background of the investigators is better than average as evidenced by their experience.

Reviewer 10C-03 (Rating: 5)
About 60 years of relevant experience in total.

7. The project management plan, including a well-defined milestone chart, schedule, financial plan, and plan for communications among the investigators and subcontractors, if any, is: 1 – very inadequate; 2 – inadequate; 3 – adequate; 4 – very good; or 5 – exceptionally good. Please comment:

Reviewer 10C-01 (Rating: 3)
The time line is reasonable, with the possible exception of only allowing 6 days to drill from surface to the Bakken formation. That would be an exceptional drilling rate. However, the accuracy of the timeline in regard to drilling and completion would only be an approximation in any case, and the actual time line would be subject to the myriad of complications that are likely to occur in the current services market and during the winter months. Drilling rig availability alone could have a huge impact on job timing. The budget submitted is simplistic, but likely reasonable in regard to the portion relegated to the VSP operation. The lack of a detail proposal from the vendor makes it difficult to judge if all the traps have been run and that the submitted cost is accurate. Again, the investigators have indicated an extensive history of experience in this area so it is likely they are on top of any of those concerns. VSP data is generally quite expensive to acquire, hence the limited application in the field. Only those who routinely do seismic work are likely to be able to justify the cost, so having this VSP data available may be especially useful to small independent operators with limited budgets. Communication plans are not evident from the proposal, but day to day operations on a drilling rig location should include sufficient interfacing with personnel to insure that all parties are kept abreast of progress.

Marathon's Response
The drilling schedule is one month for drilling from January 1 to February 1, then 6 days for logging and the VSP. A formal price quote has been obtained from the vendor for the VSP acquisition and processing, and the schedule and equipment availability confirmed.

Reviewer 10C-02 (Rating: 3)
The management plan is adequate to achieve the objective.

Reviewer 10C-03 (Rating: 5)
The management plans seems to include all vital parts. The project would benefit from including stage on which applicability of the results to a broader area is assessed.

8. The proposed purchase of equipment is: 1 – extremely poorly justified; 2 – poorly justified; 3 – justified; 4 – well justified; or 5 – extremely well justified. (Circle 5 if no equipment is to be purchased.) Please comment:

Reviewer 10C-01 (Rating: 5)
There are no indications that any equipment purchases are necessary for the success of the VSP proposal. All of the equipment supplied by the vendor is likely rented for the duration of the service.

Reviewer 10C-02 (Rating: 4)
The seismic equipment needed to generate, record, and process the data is well justified.

Reviewer 10C-03 (Rating: 5)
No equipment to be purchased.

9. The facilities and equipment available and to be purchased for the proposed research are: 1 – very inadequate; 2 – inadequate; 3 – adequate; 4 – notably good; or 5 – exceptionally good. Please comment:

Reviewer 10C-01 (Rating: 3)
The demand for all equipment and services in the Williston basin is high at this time. No guarantee is likely possible that the required equipment for all services involved will be readily available when needed. Constant vigilance by the investigators and others involved will be necessary to prevent unwanted delays or cancellations. The requested equipment and services for the VSP work are not typically available for purchase, so that is not applicable.

Marathon's Response
Schlumberger states the equipment will be available with some communication if and when the well schedule or operations change.

Reviewer 10C-02 (Rating: 4)
The contractor for the project is well established. They have the equipment, knowledge, and facilities that are notably good.

Reviewer 10C-03 (Rating: 4)
Overall facilities look good, but again bigger scale study is desirable.

10. The proposed budget "value"[1] relative to the outlined work and the financial commitment from other sources is of: 1 – very low value; 2 – low value; 3 – average value; 4 – high value; or 5 – very high value. *(See below)* Please comment:

Reviewer 10C-01 (Rating: 3)
The value of the VSP data itself, as a benefit to operators who cannot afford the cost of this technology should help create sufficient value for the project to justify the matching 50% contribution requested from the NDIC/Oil and Gas Research Council. The operator is already investing a much larger amount of capital, likely in the millions, to drill the well. That money will be spent regardless, so this is a good chance to acquire the VSP data for public use at a much discounted rate. If the project is also successful in determining fault and fracture location and orientation, that would be a bonus to the state of North Dakota in regard to the exploration and development of the Bakken formation. In a unconventional resource play that is technology driven like the Bakken, optimizing is the name of the game. There is little room to rely on chance and determining the optimum orientation or well path to maximize the productive capacity of each Bakken well is paramount to a successful program.

Reviewer 10C-02 (Rating: 4)
The value of the projected work and technical outcome would be high. If the VSP proves to be viable for the Middle Bakken it will definitely enhance the play.

Reviewer 10C-03 (Rating: 5)
Marathon provides a significant co-share.

[1] *"Value" – The value of the projected work and technical outcome for the budgeted amount of the project, based on your estimate of what the work might cost in research settings with which you are familiar.*

Financial commitment from other sources – A minimum of 50% of the total project must come from other sources to meet the program guidelines. Support less than 50% from Industrial Commission sources should be evaluated as favorable to the application.

Section C. Overall Comments and Recommendations:
Please comment in a general way about the merits and flaws of the proposed project and make a recommendation whether or not to fund. General comments:

Reviewer 10C-01 (Funding May Be Considered)
A main concern with this particular project is that much of what is proposed for funding by the NDIC/Oil and Gas Research Council is work that a prudent operator, who regularly utilizes seismic data in the search for oil and gas, should do anyway to optimize the use of seismic data. Funding normal operations is not the purpose of this fund as defined in the goals of the NDIC/Oil and Gas Research Council. Offsetting that is the rider of the possible acquisition of additional and valuable data related to fracture and fault location and orientation that does meet the NDIC/Oil and Gas Research Council goals and justify public investment in the project. If the ability to determine the fracture and fault parameters in question fails, however, the operator will still benefit by having sole access to the state funded VSP data funded for a full year, yet the goals of the NDIC/Oil and Gas Research Council may not have been met.

Reviewer 10C-02 (Funding May Be Considered)
I agree with the investigators that one of the significant unknowns in the current development of the Middle Bakken is the preferred fracture orientation and how it affects productivity. In the first Bakken Shale play the fracture orientation was directly related to the productivity of the well. If fractures and faults can be detected with VSP this could definitely enhance the success of the play. The information could be utilized to identify the best well locations and optimize the drilling direction.

The flaw I see is that regardless of natural fractures or orientation, the majority of the Middle Bakken wells have to be fracture stimulated. Which section of the Middle Bakken contributes the most production? Is the entire section productive? Does the Upper or Lower Shale contribute? Have there been any orientated cores through the Middle Bakken?

There are many unknowns, but I think the VSP could lead to a better understanding of the reservoir and how to exploit it.

Reviewer 10C-03 (Funding May Be Considered)
Although the grade for the proposal is quite high, the overall impression is not that good. Claims regarding potential use of the study results seem to be too optimistic. Although my recommendation is that "Funding May Be Considered", I would suggest that close consideration should be made and probably another reviewer's opinion will simplify decision making process.